Inspecting, Assessing, and Monitoring the Inland Lakes of the Great Lakes Cluster National Parks

FIELD MANUAL

Sampling Season 1998

Lake Michigan Ecological Research Station
Great Lakes Science Center
U.S. Geological Survey
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You are taking part in a project that involves five National Parks in three states. The study is designed to assess the conditions of inland lakes in these parks and ultimately to design an effective monitoring program that will recognize ecosystem problems before they become unmanageable. With your involvement, data can be collected simultaneously at all five parks so that we can analyze conditions relative to location and design the program accordingly. In order to ensure consistency among the parks, it is crucial that you follow these field instructions closely and make note of any deviations. These lakes are an important part of the National Parks, and this research will support their health for years to come.

This field manual is designed to be both a guide for sampling and a resource for use in the laboratory. It will guide you through a sampling period from preparing all of your equipment for use through field sampling to shipping the samples collected. In addition, instructions for proper storage at the end of the sampling season are provided. A glossary is included at the end of the manual that contains common limnology (the study of freshwater systems, especially lakes) terms and descriptions for the chemical and biological variables for which you will be sampling.

It may be a good idea to read through the manual well ahead of sampling in order to plan your schedule and to request needed guidance from supporting staff. A list of equipment required for sampling should help you inventory what you have and what you will require throughout the sampling season.

Questions should be addressed to us at the Lake Michigan Ecological Research Station. You can telephone or e-mail us with questions or comments at any time.

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Administrative questions should be addressed through your on-site supervisor who is responsible for your day-to-day schedule (exclusive of sampling), safety, payroll, time, and attendance. The project manager, who has scientific and operational control, can be reached at (219) 926-8336 ext.424 or Richard_Whitman@usgs.gov

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FIELD PREPARATION

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(Instructions adapted from YSI Instruction Manual)

Prepare the 6820 Sonde for use

Your YSI sonde requires periodic maintenance and calibration, but with proper care it is an efficient and powerful water monitoring device. Instruction manuals have been supplied to you by the manufacturer, and these should be thoroughly examined for complete instructions on functioning and care. The following instructions provide you with the day-to-day answers for using your sonde through the field season, so for any other questions you have regarding special instructions or troubleshooting, please consult the instruction and service manual. NEVER disassemble the sonde; only YSI personnel should open the unit.

Do at the beginning of the sampling season:

INSTALL THE OXYGEN MEMBRANE

- the first time, you will need to prepare the electrolyte solution; follow instructions on the bottle
- remove the dry membrane from the probe
- installation is described in the instruction manual; be sure there are no bubbles in the probe

INSTALL THE PROBES INTO THE BULKHEAD

- use the small metal rods in the maintenance kit to unscrew the port plugs for dissolved oxygen, conductivity/temperature, and pH probes
- apply a thin coat of stopcock grease to the O-rings on the connector side of one of the probes
- install the probe into the correct port (count the pins) and gently rotate until the two connectors align

- screw down the probe nut until snug using one of the rod tools
- lubricate and install the other two probes as described above
- see manual for more specific instructions for each probe

INSTALL CUP FOR STORAGE

- saturate the small sponge with water and place it in the bottom of the transport/storage cup OR place approximately 1 cm of water in the bottom of the cup--enough for humidity without covering the probes
- place the cup over the sensors carefully so that the DO membrane is not damaged
- attach cup to bulkhead; turn until secure
- more information on short-term and long-term storage is in Appendix G of the instruction manual

YSI setup

Do when necessary; at least 24 hours prior to field sampling:

CHARGE THE 610-DM

- plug the 610-DM into the wall mount adapter and charge for approximately 24 hours; BE SURE the power is turned off
- the 610-DM uses NiCad batteries which require a FULL DISCHARGE to maintain their capacity; you should discharge the battery pack COMPLETELY before re-charging.
- the 610 will beep persistently when the batteries get low
- if you intend to leave the 610 on to drain the batteries, you must set the Shutoff Time to 0 in the System Setup Menu
- you can use the wall-mount adapter while using the 610 in the laboratory to conserve batteries

Do first time out or first time after charging:

SET UP THE 610-DM

- turn on the 610-DM by pressing the power key
- if the 610-DM is turned on while attached to the 6820, it will automatically enter RUN mode; return to the Main Menu by pressing ESC key
- use arrows to highlight Setup 610 and press Enter
- to change settings, highlight the appropriate line, enter the new information and press Enter
- use the MDY date format, the forward slash for date display, the colon for time display, and the decimal point for the radix mark
- enter the current date and time 24-hour
- if you wish, set up a site list, which records names for future use
- more information of this and other setup information may be found in the 610 operations manual

SET UP THE 6820 SONDE

- choose Setup Sensors from the Main menu
- use arrows and enter keys to place bullets by the sensors installed on the 6820: Time, Temperature, Conductivity, Dissolved Oxy, Pressure-Abs, and ISE1 pH
- press ESC to return to the Main Menu
- choose Setup Parameters
- the parameters bulleted will appear on all outputs and reports
- place bullets by: Date mm/dd/yy, Time hh:mm:ss, Temp C, SpCond µS/cm, Cond µS/cm, TDS mg/L, DO sat%, DO mg/L, Depth meters, pH

Day of sampling:

CALIBRATE THE 6820 SONDE

Conductivity

- should be calibrated every **6 WEEKS** or when erroneous readings are suspected
- place ~350 ml of conductivity standard (1413 µS/cm) in a clean and dry transport cup; if you use a smaller cup, be sure the DO membrane is not damaged and that the sensors are completely submersed during calibration (conductivity standard may be made in the lab using distilled water and anhydrous potassium chloride (KCl); the solution may be re-used if you are careful not to contaminate it; note that mS/cm and mmhos/cm are equivalent)
- dry the probes, or rinse them with conductivity standard (may rinse with used standard) and carefully immerse the probes into the solution
- rotate or move the 6820 up and down to remove bubbles from the conductivity cell
- allow one minute for temperature equilibration
- from the Calibration menu on the 610-DM, select Conductivity and then SpCond to access the procedure**
- enter the value of the standard in mS/cm at 25 ^{0}C (e.g. 1.413 mS/cm or 1413 µS/cm) and press Enter
- when SpC (Specific conductance) and CND (conductivity) readings show no significant change for ~30 seconds, press Enter
- press ESC to abort a calibration or to leave the data display after successful calibration
- rinse probes with distilled water; dry off gently

** because you are calibrating specific conductance, you do not need to correct for temperature

pH

- should be calibrated **EVERY SAMPLING PERIOD** (2 weeks)
- you will need two pH buffer solutions (2-point calibration): one pH 7 and one pH 4 or 10, depending on expected pH of lakes you will be sampling
- place ~350 ml of pH 7 standard in a clean and dry transport cup or one that has been rinsed with buffer (buffer may be re-used unless there is a change in color)
- either dry probes or rinse with pH 7 standard (may rinse with used standard)
- immerse 6820 into the pH 7 standard
- wait at least one minute for temperature equilibration
- from the Calibration menu, select ISE1 pH and 2 point
- input the value of the buffer (7.00)
- when pH readings show no significant change for ~30 seconds, press Enter
- rinse the probes in water and dry them or rinse with buffer of the second pH value
- place 350 ml of buffer into a clean and dry or pre-rinsed container
- wait at least one minute for temperature equilibration
- input the value of the second buffer
- when the pH readings show no significant change for ~30 seconds, press Enter
- press ESC to abort a calibration or to leave the data display after a successful calibration
- rinse probe with distilled water

Dissolved Oxygen

- should be calibrated on **EVERY SAMPLING DAY**
- membrane should be changed whenever it is damaged or bubbles appear underneath it
- after a membrane is changed, leave probe in moist air in RUN mode for 15-30 minutes

- to calibrate probe, place ~3 mm of water or the small wet YSI sponge in the bottom of transport cup
- place 6820 sonde into cup, and engage only 1-2 threads of the cup to ensure ventilation
- wait ~10 minutes for the air to become water-saturated and the temperature to equilibrate
- from the Calibration menu, select Dissolved Oxy and DO%
- enter the barometric pressure in mm of mercury (not corrected to sea level); if you do not have a mercury barometer, you can: (1) call a local airport, TV, or radio station for corrected reading and "uncorrect" it by subtracting 26 mm for every 1000 ft above sea level, (2) use a recently calibrated dial barometer and "uncorrect," as above, or (3) use Table 2 in Appendix F of the YSI instruction manual if weather is fair and stable
- when the DO and DO% readings show no significant change for ~30 seconds, press Enter
- press ESC to abort a calibration or to leave the data display after a successful calibration

Depth

- should be calibrated on **EVERY SAMPLING DAY** in field, prior to sampling
- leave the 6820 probes in water-saturated air
- from the Calibration menu, select Pressure-Abs and input 0.00 at the prompt
- when the DEP readings show no significant change for ~30 seconds, press ENTER
- press ESC to abort a calibration or to leave the data display after a successful calibration

Field Equipment List

General Items:
data sheets and pen/pencil
thermometer for air temperature
Secchi disk
GPS
depth finder
laboratory tape
permanent marker-- sharpie
ice packs and cooler
alcohol
extra distilled water
extra battery for depth finder

Depth Profiles:
YSI 6820 or Hydrolab sonde
610 DM or surveyor 4 display
flow-through probe protector
cable

Water Chemistry:
Kemmerer
lab bottles

Phytoplankton:
(Kemmerer)
plastic small mouth 1 L bottles
Lugol's solution w/eyedropper

Chlorophyll:
(Kemmerer)
2 L bottle (if filtering on shore)
graduated cylinder
tweezers
filters— Millipore AA
filtering apparatus
hand pump
aluminum foil
small vials for filter storage

Zooplankton:
plankton net
spray bottle (with DI water)
squeeze bottle
plastic sample jars
(Lugol's solution w/eyedropper)
Alka-Seltzer tablets
small container for narcotizing

Benthos & Sediment Chem.:
Ekman dredge
wash bucket with sieve
simple wash container to rinse sieve-- bucket or bowl
plastic wide-mouth sample bottles (alcohol)
IN **AUGUST**
teflon pan
teflon ladle
lab bottles
paper towel (for wiping sediment jars)

Boat and Safety:
anchor, rope
paddles
life vests
decontaminating salt solution
canoe straps for car
phone/radio
first aid kit
drinking water
sunscreen
rain gear

Bottles required for sampling one lake

It is best to label bottles, with as much information as you can, before going in the field. This will allow you to keep track of what samples have been collected. On the labels include:

Park Name
Lake Name
Date / Time
Depth
Tow Length (zooplankton)
Volume Water Filtered (chlorophyll)
Littoral/Limnetic (benthos)
Replicate # or letter (1 of 3, etc.)

The laboratory chemistry bottles have sticker labels to apply. They should include the following information:

- In the section marked "parameter" you should write "Schedule A." This is the code for our list of parameters at the lab (except in August).
- Fill in lake name and site information for sample identification.
- Preservative is labeled with a sticker, but you may circle it on the label just to be safe.
- Also, you should number each bottle with your own numbering system, since there are so many bottles. This is just another safety since some of the bottles will have the exact same labels otherwise.
- Be sure to sign each label.

In order to facilitate mailing samples to the laboratory in a timely manner, you can fill out the majority of the chain of custody form, including lake name, sample type, etc. before sampling. Items such as time will need to be filled out after sampling.

For laboratory chemistry:

During **stratification**, you will use the following bottles:

3, 1 L plastic bottles with no preservative for WATER (limnetic-epi, limnetic-hyp, littoral)
3, brown glass bottles with H_2SO_4 for WATER (limnetic-epi, limnetic-hyp, littoral)
3, smaller plastic bottles with HNO_3 for WATER (limnetic-epi, limnetic-hyp, littoral)
In **AUGUST 2, 8 oz. glass jars with white caps for SEDIMENT (limnetic, littoral)**

For benthos:
6, 1 L wide-mouth plastic w/ metal lids (3 limnetic, 3 littoral)

For zooplankton:
3, 250 ml wide-mouth plastic w/ plastic lids (3 limnetic)

For phytoplankton:
3, 1 L small-mouth plastic w/ plastic lids (3 limnetic)

For chlorophyll:
1 small plastic vial

Total = 21 bottles + 1 vial (In **AUGUST**: 23 bottles + 1 vial)

FIELD SAMPLING

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Field notebooks:

One of the most important records we have of conditions on the day of sampling is your field notebook. Weather and lake conditions can be very important in drawing conclusions about water chemistry and biology. It is often not possible to recall specific situations when the data is reviewed later, so take some time to fill out your field notebook. There is plenty of writing space, so write as much as you want. Anything that strikes you including water appearance, weather conditions, vegetation, or wildlife should be recorded in the notebook.

SAMPLE DATA SHEET:

Date (mm/dd/yy) 08/09/98 **Time(24 hr)** 1320

Lake Name Lake Michigan

Site Limnetic **Analysts** Smith and Jones

Temperature ^{0}**C** 32 **Wind Speed/Direction** 5-7 SW

Skies and other weather conditions Sunny and hazy, light breeze; quite humid; visibility moderate; cirrus clouds

Weather History Sunny/ hot several days; thunderstorms last night

Other Observations looks like much suspended sediment in the water column; many people on the beach; several recreational boats, jetskis, and swimmers in the water; water temperature is relatively warm; many seagulls down the beach from people; choppy water nearshore, calmer open water

Site Depth 6 m **Shoreward Distance** 20 **(m)**

Secchi Depth (m) 3.4 **GPS**

Chlorophyll filtered 1800 **ml**

* plankton net hit bottom; we took another sample (labeled B2)
* also, sediment chemistry sample was a composite of three subsamples--one of which was taken from only the top ~2 inches of sediment

Sampling Guide

Typical sampling order:

-- (a) and (b) denote 2 persons' tasks
-- the most important thing to remember is to take your water samples before your sediment samples

1. GPS (a)
   field data sheet (a)
   air temperature (a)
   Secchi disk (a)
   YSI/Hydrolab (b)

2. Kemmerer:
   water chemistry (a)
   phytoplankton (a)
   chlorophyll (a)
   Zooplankton (b)

3. Ekman (a/b)
   benthos

YSI profile

Equipment:
YSI 6820 or Hydrolab sonde
610 DM or surveyor 4 data display
flow-through probe protector
cable

Procedure (if using a Hydrolab sonde, follow instructions in manual):

- attach cable to the top of the sonde and to the 610-DM; BE CAREFUL NOT TO LET CONNECTIONS GET WET; also attach the field cable's strain relief connector to the sonde bail and the "safety" connector at the other end to the boat
- remove the transport/storage cup from the YSI probes and carefully replace with flow-through probe protector
- turn on the 610-DM (it will be in Run mode)
- hold the 6820 at the surface so the probes are submerged in the water; it will take ~5 minutes for the probes to equilibrate
- calibrate depth to 0 while holding the YSI at surface
- when you are ready to begin profiling, you will press "A" to add a reading; for the surface reading, you will be required to set up the file into which all readings will be entered* (see next page)
- choose your file name and press enter and "Y" for a new file
- you have the option of entering weather data into the program
- after the reading has been taken, slowly lower the sonde 1 meter; watch the depth on the digital readout;
- when you are as close as possible to 1 meter and the reading has stabilized (it will fluctuate slightly), press "A" to add the reading, and then press "Y" when the correct file name is displayed
- lower the sonde 1 meter for another reading
- you will continue this process until you reach the bottom of the lake; this will be obvious because the some readings will fluctuate erratically when it touches bottom (the DO, most obviously)

- after all of the readings have been collected, bring the sonde to the surface
- remove the flow-through probe protector and replace with storage/transport cup; the cable may stay attached until you are back on shore to protect against moisture; turn off 610-DM
- repeat the procedure in littoral zone by taking readings at surface and 1m; take 2 m reading if site is deep enough

* file names should be consistent; the format includes the park, date, and lake; BOTH limnetic and littoral can be entered into the same file. Please use the following examples:

v71298L (Voyageurs, July 12, 1998, Locator Lake)
v71298M (Voyageurs, July 12, 1998, Mukooda Lake)
is71298S (Isle Royale, July 12, 1998, Siskiwit Lake)
is71298G (Isle Royale, July 12, 1998, Sargent Lake)
p71298B (Pictured Rocks, July 12, 1998, Beaver Lake)
p71298GS (Pictured Rocks, July 12, 1998, Grand Sable Lake)
s71298L (Sleeping Bear Dunes, July 12, 1998, Loon Lake)
s71298NB (Sleeping Bear Dunes, July 12, 1998, North Bar Lk.)
s71298R (Sleeping Bear Dunes, July 12, 1998, Round Lake)
in71298L (Indiana Dunes, July 12, 1998, Long Lake)

Phytoplankton

Equipment:
Kemmerer
1 L plastic small-mouthed bottles (6 per lake)
Lugol's solution in eye-dropper bottle

Procedure:
- collect sample from 1 meter below the lake surface; when sampler is pulled out of the water, squeeze the stoppers in more tightly to prevent leaking; DO NOT rest sampler on the release valve— your lap or the boat will be drenched
- rinse sample bottle with a small amount of sample water
- fill bottle to mouth; add Lugol's until the sample is the color of weak tea (NOT coffee); mix gently
- repeat sampling 2 more times for a total of 3 samples per site
- store in cool, dark location (cooler after collected)
- Lugol's will dye the plastic, so make certain your sample water is the color of weak tea, not just the bottle
- check sample in 1-2 weeks to make certain the water is retaining color; additional Lugol's should be added if the sample is no longer the color of weak tea

Equipment:
Kemmerer
sampling bottles from lab
-- 3, 1 L plastic bottles (2 lim, 1 for litt)
-- 3, brown glass bottles preserved with H_2SO_4 (2 lim, 1 litt)
-- 3, smaller plastic bottles preserved with HNO_3 (2 lim, 1 for litt)
cooler and ice packs

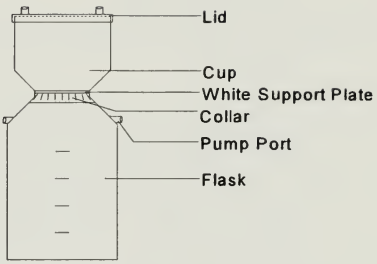
Procedure:
Littoral zone—
• take samples from 1 meter and fill the one un-preserved and one preserved sample bottle to bottle shoulder. ***DO NOT** rinse out the sample bottles with lake water; the bottles were prepared in the lab

Limnetic zone—
During Stratification—
• take one sample from the epilimnion (epi) at 1 meter below the water surface and fill one un-preserved and two preserved bottles
• take one sample from the hypolimnion (hyp) at 1 meter above the bottom and fill one un-preserved and two preserved bottles
During Lake Mixing—
• take sample from the epilimnion and fill sample bottles 1/2 full
• take sample from the hypolimnion and fill the bottles the rest of the way to the shoulder
• mix gently
• write on bottle label and chain of custody form that the sample is a composite
• store samples on ice and ship overnight to the lab

Be sure to write on the bottle labels and chain of custody form the lake name, site (littoral or limnetic), if sample is a composite, and depth (epilimnion or hypolimnion).

Chlorophyll a

Equipment:
Kemmerer
2-liter bottles (if filtering on shore)
filtering apparatus (at right)
graduated cylinder
tweezers
filters— Millipore AA
hand pump
aluminum foil
small vials for filter storage
cooler and ice packs



Equipment set-up:
- attach clear rubber caps to ports in lid and one side of flask; hand pump attaches to other port in the flask
- place one o-ring under the support plate and one on the cup; these are essential for correct operation of the filtering apparatus

Procedure:
- collect sample from 1 meter below the lake surface; when Kemmerer is pulled out of the water, squeeze the stoppers in more tightly to prevent leaking; DO NOT rest on release valve— your lap or the boat will be drenched
- if filtering on shore, rinse 2-liter bottle with a small amount of water from the Kemmerer before filling; immediately place container in a cool, shaded place to prevent chlorophyll photo-degradation.
- if conditions permit, filtering may be done in the boat

filtering:

- set up filtering apparatus without filter and flush with 25 ml of filtered or deionized water
- using tweezers, place one Millipore AA filter on the support plate and screw cup into place without tearing the filter
- rinse graduated cylinder with small amount of sample water and then

measure a known quantity of your water sample
- keep sample and filter out of direct sunlight; cover as much as possible during filtering
- squeeze the hand pump to create slight pressure and then pour sample into cup
- you will need to squeeze the pump periodically to maintain the pressure
- flask will be FULL after ~900 ml have been filtered; release pump pressure; carefully remove cup and support plate by unscrewing the white collar, empty the flask— you do not need this water— reassemble, and continue filtering
- continue filtering until filter is clogged, filter is green, or 2000 ml of sample have been filtered
- release pump pressure with finger release; unscrew the collar to remove cup from the flask
- using tweezers, fold the filter in half as it rests on the support plate (do not touch the filtrate area); fold in half again and place filter on a small piece of aluminum foil
- fold the foil several times to enclose the filter
- label foil and vial with lake name, site, date, time, and volume of water filtered
- store vial on ice until return to lab; then store in freezer
- rinse cup and support plate with filtered or deionized water

Zooplankton

Equipment:
plankton net
spray bottle (filled with distilled water)
squeeze bottle
250 ml plastic wide-mouthed bottles with plastic lids (6 per lake)
Lugol's solution in eye-dropper bottle
Alka Seltzer tablets
small container for narcotizing
extra distilled water

Limnetic Zone Procedure:

- slowly lower the plankton net to within 1 meter of the lake's bottom; the weight of the bucket should pull the net down at a constant rate
- retrieve the net using a gentle hand-over-hand motion (approximately 0.5 to 1 meter per second) while raising vertically
- at the surface, gently lower and raise the net in the water to rinse down the sides without allowing more water to be added though the top
- holding the net out of the water, use the spray bottle full of lake water or "clean" water to rinse down the OUTSIDE of the net
- rest the sample bucket in the plastic container containing Alka Seltzer solution; remove the net
- leave the bucket in the solution for about one minute to narcotize the organisms
- rinse the inside of the bucket and the "screened" areas into the container with the squeeze bottle full of **filtered** lake water, distilled water, or tap water (not regular lake water)
- add Lugol's solution until the sample is the color of weak tea; mix gently
- repeat 2 more times for a total of 3 samples per site
- store in cool, dark location (refrigerate if possible); add Lugol's to sample every 3-6 months to retain color and to preserve properly

Equipment:
Ekman grab sampler
wash bucket with No. 30 sieve bottom
simple wash container (bucket, bowl, or bottle to rinse sieve)
1 L plastic wide-mouth sample bottles (6 per lake + extras as needed)
alcohol preservative

Procedure:
- carefully set springs on Ekman while it is resting on the boat floor or seat; DO NOT set springs with apparatus in your lap
- slowly lower Ekman over the side of boat and keep it vertical from the boat to the bottom
- when Ekman has reached the bottom, trip dredge by dropping messenger; you should either hear it trip or feel it in the rope
- lift Ekman to water surface with a smooth even motion, but do not lift out of the water
- keeping Ekman under the surface, quickly slip sieve bucket under dredge
- lift these (together) up to the edge of the boat
- empty Ekman into the sieve bucket by pulling up the sides (jaws) and rinsing the inside of the Ekman with lake water; releasing the spring-loaded sides may make emptying easier; minimize the amount of water you pour into the bucket to make sieving easier
- when the Ekman dredge has been emptied, put it aside; rinse the sample by sloshing, twisting, and swirling the bucket while thrusting it up and down in the water; do not let water run over the top of the bucket, as this makes sieving more difficult
- if your sample is full of fine clays, it may also help to mix the sample gently with your hand; be sure to rinse your hand or glove into the sample if there is sediment on it
- your final sample should not have muck and fine silt-- the small amount of water in your sample should be clear
- concentrate the sample materials to one side of the bucket by holding it at an angle at the water surface and splashing the bottom of the

bucket; empty contents into sample container

- the remaining small particles can be rinsed into the bottle by pouring water over the bottom of the screen with your simple wash container
- repeat 2 more times for a total of three samples at each site (lim& litt)
- if your sample fills 1/3 of the jar, fill it to the top with ethanol; if there is more sample than 1/3 (including water), you will have to divide it so that each jar is only 1/3 full with your collected sample; 2/3 of the bottle must be ethanol in order to preserve the organisms properly

Sediment Chemistry
IN **AUGUST**

Equipment:
Ekman grab sampler
teflon pan
teflon ladle
sample bottles from Quanterra
2 white cap 8 oz glass jars for composite sediment (1 Lim, 1 Litt)
(NOTE: jars will be included in shipment; follow any specific instructions sent by Quanterra)

Procedure:
- collect an Ekman grab sample
- if the sample is a solid consistency, open the lid of the Ekman, scoop out sample and fill bottle 1/3 full of sample
- if your sample is a liquid or mucky consistency, empty the Ekman into the Teflon pan and then scoop out and fill bottles 1/3 full of sample
- repeat 2 more times until bottle is full
- write on the sample bottle and on the chain of custody form that sediment samples are composited, but unmixed

Note: decrease possibility of contamination by minimizing the amount of equipment that comes into contact with the sample

AFTER FIELD SAMPLING

AFTER FIELD SAMPLING

When you return from the field, many of the samples will need attention. Vials containing chlorophyll samples should be placed in a freezer as soon as possible. Laboratory bottles for chemical analysis will need to be shipped AS SOON AS POSSIBLE. Many of the assays must be started within 24 hours of collection.

SHIPPING SAMPLES TO QUANTERRA LABORATORY:

Laboratory bottles need to be inventoried on the **chain of custody forms** as you pack them for shipping. The form requires a complete description of each bottle included in the cooler. You need to fill in the lake name, site, date, time, and sample type (water or sediment). In the section "Analysis," write "Schedule A." Be sure your park's name is on the form, and don't forget to sign each sheet.

When packing the bottles in the cooler, the small plastic bottle of water labeled "temperature" should be shipped with the bottles to the laboratory. This allows them to determine the ambient temperature of the samples upon arrival at the lab. Add as many ice packs as possible in order to maintain a cool temperature during shipping. Also, use ALL of the packing materials they have supplied, and more if materials are available. We have had problems with broken bottles in the past. Finally, include the chain of custody form in the package, and place the custody seal, with signature, over the edge of the cooler.

FIELD EQUIPMENT:

Preventing the spread of zebra mussels and other exotics is very important to consider because we are sampling many lakes including some with known infestations. Adult mussels can be picked off of equipment, but veligers (juveniles) are too small to be seen by visual inspection. Decontamination is absolutely necessary between lakes, and all sampling equipment should be included in the protocol. Those of you who sample more than one lake on a single day will need to bring along salt or a salt solution and a large bucket for decontaminating your

equipment. All of the equipment should be immersed in a 30 ppt salt solution for one minute (this amounts to 30 grams of salt, softener or table salt, in 1 quart of water). Thoroughly rinse equipment after the salt solution. A high-pressure water sprayer or a sponge should be used to clean the boat; and be careful to avoid transporting any lake water or vegetation to other locations.

Another option is available for those of you who sample only one lake in a day. At the end of the sampling day, hang up nets and other equipment and allow everything to dry out **completely**. This should effectively kill the veligers attached to your equipment.

Even after decontamination, all of the equipment should be left where it can dry out overnight. Cases for the Kemmerer and Ekman should be left open, and the plankton net should be hung up to dry.

YSI DATA UPLOADING:

The 610-DM data should be uploaded to a computer after EACH sampling day, using the PC6000 software. If it is not on your computer already, you will need to load PC6000 onto the hard drive.

Installing PC6000:

- should be installed onto an IBM-compatible personal computer with at least 256 KB of RAM and DOS 3.0 or later
- to install through DOS, insert disk and switch to that drive (e.g., type A: at the C:\ prompt for the A drive)
- type INSTALL <destination> where destination is the drive and directory in which you want the PC6000 files to be installed (e.g., type INSTALL C:\PC6000)

Uploading from the 610-DM:

- run PC6000 on your personal computer
- select setup from the menu bar, verify that the Baud Rate is 9600 and the Comm Port is the correct one (change if necessary) and press ENTER

- connect the null modem cable to the appropriate PC communications port
- press ESC on the PC; select Sonde from the menu bar; and press ENTER
- a message will indicate that no sonde is connected; press ENTER again
- connect the other end of the null modem cable to the 610 DB-9 pigtail adapter
- turn on the 610 if necessary and select System Setup from the 610 Main Menu
- verify that the Baud Rate is 9600 (change if necessary); press ESC to return to Main Menu

on the 610-DM. . .

- select Communications from the 610 Main menu
- select Kermit610--> PC
- select the file you wish to send, or select Send All Files
- if you are using a cable longer than 50 feet and get too many errors, lower the baud rate in the PC6000 and 610-DM setups and try again
- additional information about uploading is in Section 8.4 of the 610 Operations Manual

Uploading the weather data:

- this is not uploaded using Kermit; it must be sent by performing Dump 610 Setup
- while in Sonde mode in PC6000, press F3 to capture weather data to a file
- choose Flat ASCII Text and enter a file name (this file will contain all weather information currently in the 610)
- choose Setup 610 from the 610 Main Menu
- choose Dump 610 Setup and press "Y"

Deleting files from the 610:

- once you have uploaded all of the files and weather information to the PC and double-checked uploading success, you may delete them from the 610 (although the memory can hold MANY profiles before being full)
- to delete all files, choose Setup 610 from the Main Menu
- choose Delete All Files and press "Y"
- to delete a particular file, choose 610 File System from the Main Menu
- choose the file name; Delete File; and press "Y" (deleting a file also erases its associated weather data)

SHIPPING BENTHOS SAMPLES:

Because ethanol is a flammable liquid, very strict instructions must be followed to ship samples. The U.S. Postal Service will not ship ethanol under any circumstances. Federal Express will accept these samples, but these instructions must be followed exactly, or your shipment will be returned to you.

If you have any questions about special situations or instructions, it would probably be best for you to call Federal Express. The toll-free number is at the top of the shipping form. Be sure the bottles are sealed tightly with tape and labeled.

THE FORM (you must include **2** Federal Express Dangerous Goods Shipping forms for each shipment):

Number 1-4 on the shipping form are self-explanatory.

Number 5, you should check off " (4) DANGEROUS GOODS."

Number 6, you will need to fill in the weight of the package being shipped.

For "TRANSPORT DETAILS", you want "passenger and cargo aircraft," so delete the other.

For "SHIPMENT TYPE", you want "non-radioactive," so delete the other.

The bottom section "Nature and Quantity of Dangerous Goods" (volume printed is an example):

Proper shipping name	class/ division	UN/ ID no.	Packaging Group	Subsid risk	Quant & type packing	Packag inst.	Authoriz
Ethanol	3	UN1170	II		1 fibreboard box X 3L	Y305	Ltd. Qty

(fill in YOUR package volume)

You may want to ask your local Federal Express carrier about filling in the section "Packaging instructions" because we have gotten conflicting explanations. Some carriers require you to leave that space blank.

The box in which you ship the samples should have the appropriate symbol:

on it, so your packaging instructions will be Y305. If the box does not have a symbol on it, the packaging instruction code is 305.

Fill out the emergency phone number, your name, and sign the sheets. **These samples will all be sent to the Lake Michigan Ecological Research Station when you are instructed to do so.**

THE PACKAGE:

There must be at least one package orientation symbol on the side of the box. You can photocopy the ones you receive and tape them on each

package, or use stickers provided by Federal Express. There should be one Flammable Liquid sticker on the side of the box as well. You need to add a label that says "Ltd Qty" and "UN1170" if your box does not have this symbol on it:

The two shipping forms can be placed in the plastic window folded loosely (since they're different sizes); the shipper will take care of it.

SHIPPING ZOOPLANKTON AND PHYTOPLANKTON:

These samples are not considered dangerous goods, so you may ship them with any of the carriers your park uses. The zooplankton jars have a tendency to leak, so you will need to tape around the lid of each jar. When packaging the jars, make sure they are all packed upright. Pack them tightly, but do not put jars in sideways to fill up empty spaces—use paper or other packaging material.

The phytoplankton bottles should have been filled completely. Again, ship all samples upright, and pack boxes tightly. **Ship all samples to the Lake Michigan Ecological Research Station.**

AT THE END OF THE FIELD SEASON

AT THE END OF THE FIELD SEASON

It is very important to prepare your field equipment for long-term storage so that everything is in working order at the beginning of next season. Make certain all sampling equipment has been rinsed and dried before packing in carrying cases to prevent rust and mildew. The Kemmerer should be packed in an open position. All water bottles should be emptied and dried. Pack things away in a clean and dry location where they will not be damaged.

The YSI will need special attention before storing it. Of the probes, only the conductivity/temperature and dissolved oxygen probes will remain on the sonde during storage. The pH probe should be removed and placed in its original container (that in which it was shipped) in a 2M KCl solution. It is imperative that you not use distilled water for storing this probe. The open port should be covered with the provided plug.

Sampling equipment and supplies (jars, bottles, filters, aluminum foil, etc.) should be inventoried, and a list should be sent to the Lake Michigan Ecological Research Station at the end of the season.

LAKE CHARACTERISTICS

LAKE CHARACTERISTICS

Each park participating in this study has selected two representative lakes to be studied in the development of baseline information and a pilot monitoring program. The lakes were selected according to their significance, resource representation, or potential for degradation. Our understanding of the comparative limnology of these lakes is essential for the establishment of this monitoring network and the ultimate characterization of Great Lakes National Parks inland lakes. The lakes described below are arranged latitudinally. Obvious clinal differences exist; more subtle ecological variation will emerge in large part through your efforts.

Long Lake at Indiana Dunes National Lakeshore is a long, shallow lake that originated as an interdunal lake. The surface area measures 43.1 hectares (106.5 acres), and maximum depth is only 2 meters. Long Lake was once substantially larger, but years ago, a road was constructed that split the lake into two parts. Sediment infilling and nutrient input have promoted eutrophication of the lake, and macrophytes cover much of the lake by late summer. The sediment is sand, and there is organic material, including much plant matter, on the sediment surface.

Located in Sleeping Bear Dunes National Lakeshore, **Loon Lake** is a popular location for swimming and recreation. The lake is part of the Platte River watershed, and therefore it has the potential for contamination from sources along the entire watershed. The surface area measures 38.5 hectares (95.1 acres). Loon Lake has a mean depth of 9 meters and a maximum depth of 20 meters. The flushing rate is quite high, so although the lake receives nutrient input from upstream sites, water moves through

the basin relatively quickly. Sediments are fine silts and sand, and the water is relatively clear. The lake is dimictic, but in winter, the channel of the Platte River that runs through Loon Lake only freezes periodically. A few residences are located around the lake, but most activity associated with the lake is recreational. We suspect zebra mussel contamination at this lake.

North Bar Lake is also located in Sleeping Bear Dunes National Lakeshore. This lake lies parallel to Lake Michigan, and only a sand bar separates the two bodies of water. This sand barrier is occasionally open, and water flows between the two lakes. (At one time Long Lake probably was at this stage of geological development.) North Bar Lake is used heavily by recreationists, and dune and bank erosion is a management problem. The lake shows evidence of high nutrients by its many macrophytes along the shore. The sediments are fine silt and sand, and water clarity is fairly low. North Bar lake is contaminated with zebra mussels. Maximum depth is 9.8 meters.

Beaver Lake lies slightly inland of Lake Superior in Pictured Rocks National Lakeshore. This large lake (308.4 hectares; 762.1 acres) is a popular fishing site, but other recreation is limited. The shoreline is sandy sediment, and there is a steep dropoff into the limnetic zone. Mean depth is 6.8 meters, and the maximum depth is 13 meters. The water is quite clear, with a mean Secchi depth, during the summer, of over 5 meters. Only rarely does Beaver Lake stratify, so it can be described as a cold polymictic lake. Little Beaver Lake is connected to Beaver Lake. Beaver Creek flows from Beaver Lake out to Lake Superior.

In the eastern area of Pictured Rocks National Lakeshore is **Grand Sable Lake**, with a surface area of 306.6 hectares (757.6 acres). Sable Creek flows from Grand Sable Lake north to Lake Superior. Many bays in the lake result in a high shoreline

development factor, 1.60. The lake is deeper than Beaver Lake; mean depth is 9.7 meters, and maximum depth is 20.1 meters. Over the summer, mean Secchi depth is around 3 meters. The water stays quite clear throughout the year. Sediments are mostly sand with some organic material. The lake can be described as dimictic; however, the southern portion of the lake typically does not stratify (Kamke 1987).

Siskiwit Lake at Isle Royale National Park is the largest and deepest of the lakes included in this study. Surface area of the lake is 1604.9 hectares (3965.8 acres). Mean depth is 25 meters, and the maximum depth is 49 meters. Siskiwit Lake is an oligotrophic lake with very clear water; Secchi depth, during summer, is close to 6 meters. The sediment is very rocky in the limnetic zone, and somewhat sandy, with much rock and timber debris, in the littoral zone. Because of its proximity to Lake Superior and its size, Siskiwit Lake is susceptible to wind-induced waves. Several islands dot the lake, and its shoreline has many bays and land projections. The lake is fished, and some species present include brook trout, lake trout, northern pike, and yellow perch. The watershed is heavily forested, and the lake lies within a mile of Lake Superior.

Located on the other side of the greenstone ridge at Isle Royale National Park, **Sargent Lake** is considerably smaller than Siskiwit Lake. Surface area measures 141.5 hectares (349.7 acres). The mean depth is 8.2 meters, and the maximum depth is 14.7 meters. Sargent Lake is a clear, oligotrophic lake with pebbly sediment in the littoral zone and thick black muddy sediment in the limnetic zone. The watershed around Sargent Lake is heavily forested, and the shoreline is convoluted due to many bays and land protrusions, in addition to an island.

Mukooda Lake lies in the southern portion of Voyageurs National Park. Surface area measures 305 hectares (753.6 acres). The mean depth is 12 meters, and maximum depth is 23 meters. Shoreline development factor equals 1.3, and it increases to 1.43 when the three islands are included. It is a clear water, dimictic lake. The DNR stocks fish in Mukooda Lake through the year. Lake trout fishing is managed in winter, and large mouth bass and crappie are stocked in the summer. There are extensive beds of bullrush in the southeast portion of the lake, and submergents in the northern portion.

Further north in Voyageurs National Park, **Locator Lake** is in a series of lakes connected by open channels. Its surface area measures 56.7 hectares (140 acres). Mean depth is 8.1 meters, and maximum depth is 15.9 meters. Shoreline development factor equals 2.45. It is a dark water lake due to humic acids. Aquatic vegetation is sparse, and the shoreline is rock and rubble. Locator Lake is the lowest in a string of four lakes, and Cranberry Creek flows out of the lake.

LIMNOLOGY TERMS

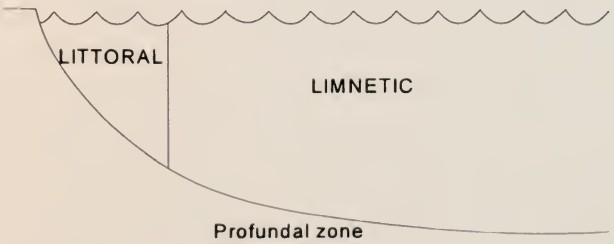
LIMNOLOGY TERMS

(This glossary includes general concepts for many of the terms you will encounter. Complete definitions would require much more elaboration.)

Light-defined lake zones:

littoral zone— This is the shallow area of the lake where light is able to penetrate to the bottom. Rooted aquatic plants can grow in this zone. The area of this zone is widely variable among lakes and depends on water clarity, and lake morphometry.

limnetic zone— The limnetic zone is differentiated from the littoral zone by depth of the water. In the limnetic zone, light does not penetrate to the lake bottom.



profundal zone— This area is located where light does not penetrate to the bottom. It includes the sediment where plants are unable to grow due to insufficient light (aphotic zone).

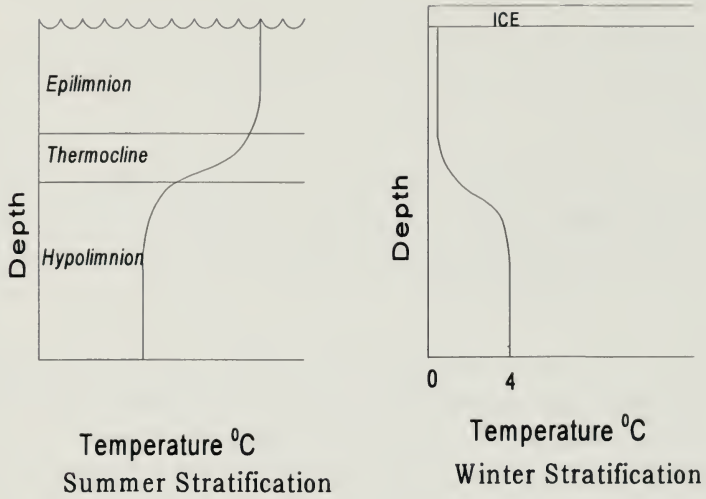
Temperature-related terms:

epilimnion— The upper layer of thermally stratified water, the epilimnion is the layer mixed by wind and wave action. This layer is the warmest well-mixed layer during summer stratification.

hypolimnion— This is the lower, cooler water layer that exists during summer stratification.

thermocline— This layer separates the epilimnion and hypolimnion. This layer is characterized by the greatest temperature change with depth.

thermal stratification— In thermal stratification, the lake is separated into water layers at distinct temperatures due to differences in water density. Wind and waves mix the top layer of water (epilimnion) and keep the temperature homogeneous. The water below the thermocline is not mixed with the rest of the water column by moderate winds. Some lakes maintain stratification most of the time while others only rarely stratify. Thickness of layers depends on water clarity, wind, and other factors.



overturn— This process mixes the entire water column, rather than just the epilimnion. It is a result of temperature changes or wind and wave mixing. In temperate, dimictic lakes, when the surface water is warmed, in spring, or cooled, in fall, it begins to sink. Water is most dense at 4 °C. After winter, as the surface ice melts, the cool water begins to sink when it reaches 4 °C. As the water continues to warm, the layers mix, and the nutrient-rich bottom water is brought to the surface. After summer, the surface water cools, and when it reaches 4 °C, it sinks, and the upper layers are replaced.

dimictic lakes— In these lakes, the entire water column is mixed twice a year: spring and fall. Dimictic lakes are directly stratified in summer and inversely stratified in winter.

cold monomictic lakes— These are primarily Arctic and mountain lakes in which the water temperature never exceeds 4 ^{0}C. These lakes mix only once during the year, in summer.

warm monomictic lakes— A typical coastal lake type, warm monomictic lakes mix in winter, and stratify in summer. The temperature never falls below 4 ^{0}C, and therefore these lakes never freeze.

oligomictic lakes— Mixing in these lakes is rare, at irregular intervals, and quickly done. Water temperature is always above 4 ^{0}C, and these are usually tropical lakes.

polymictic lakes— Continuous or frequent circulation characterizes a polymictic lake. Cold polymictic lakes always have a temperature around 4 ^{0}C, and warm polymictic lakes have temperatures far above 4 ^{0}C.

Lake types and general terms:

eutrophic lake— This is a lake with high nutrients and, therefore, high primary productivity (algae and plants). Blue-green 'algae' are characteristically extensive in these lakes, especially in summer. The littoral zone is typically broad with abundant plants. Due to high plant productivity, there is a great deal of biomass and decomposition in the profundal zone with few benthic species. In the summer, there is often depleted oxygen in the hypolimnion and throughout the lake in hypereutrophic lakes

oligotrophic lake— Low nutrients and transparent water characterize these lakes. There is low productivity, and the benthic fauna is highly diverse but low in number. The basin is typically deep with steep banks. The sediments are typically low in organic

matter.

shoreline development factor (sdf)— This number describes the shape of a lake. The shoreline development factor is calculated as "The ratio of the length of the shoreline (L) to the circumference of a circle of area equal to that of the lake" (Wetzel 1983). A perfectly circular lake would have an sdf of 1. Irregular shorelines have higher sdf values and generally higher productivity. Bays and inlets can increase the sdf value significantly.

Water chemistry:

dissolved oxygen— Oxygen is the most important element in a lake. Dissolved in water, it is available from atmospheric sources and primary producers. Aerobic organisms and decomposition both use oxygen, so its availability is imperative to lake health. The balance between oxygen supply from photosynthesis and oxygen consumption by organisms is dependent on many variables including water temperature, primary productivity, and nutrient abundance. Oxygen is more soluble in cold water. Oxygen concentrations vary with depth, and seasonal changes have a significant effect on oxygen.

temperature— Temperature has a profound influence on the chemical, physical, and biological characteristics of lakes (see lake stratification)

specific conductance— A measurement of the amount of current conducted between two electrodes 1 cm apart, specific conductance measures a solution's resistence to electrical flow. Mathematically, conductance is the reciprocal of resistence. A higher conductance means there are more ions in the water; water with fewer dissolved components has a lower conductance.

pH— This measurement refers to the concentration of free H^+ ions in water. Water with a pH of 7 is neutral with an equal concentration of H^+ and OH^- ions. Addition of acids, salts, and bases changes the balance of these ions. Adding acids decreases the pH (pH <7), and adding bases increases the pH (pH >7).

turbidity— A measurement of water clarity, turbidity causes light to be scattered in water. Several variables factor into this measurement, including suspended particles, phytoplankton biomass, and dissolved chemicals. Knowing the turbidity can help one determine light penetration in the water column, which affects primary productivity.

Secchi disk transparency— The Secchi disk is used to determine light penetration, which is a function of turbidity. The Secchi disk is lowered over the side of a boat, and the depth at which it can no longer be seen is averaged with the depth at which it can be seen again when raised. At the Secchi depth, ~10% of surface light is penetrating the water.

sulfate— One of the major anions in water, sulfate ($SO_4^{=}$) is the dominant dissolved sulfur form in a lake. Sulfate comes from natural sources, but pollution has become an important source in recent years. High sulfate often indicates acidic conditions. The cycle of sulfur in the water is complex, and many chemical forms are created through biological and chemical processes of decomposition, primary productivity, and sulfur oxidation and reduction.

chloride— Another major anion, chloride (Cl^-) follows sulfate in abundance. Chloride usually relates directly to salinity, oxygen solubility, and osmotic function in organisms. Chloride forms ionic bonds with cations, including sodium, potassium, calcium, and magnesium.

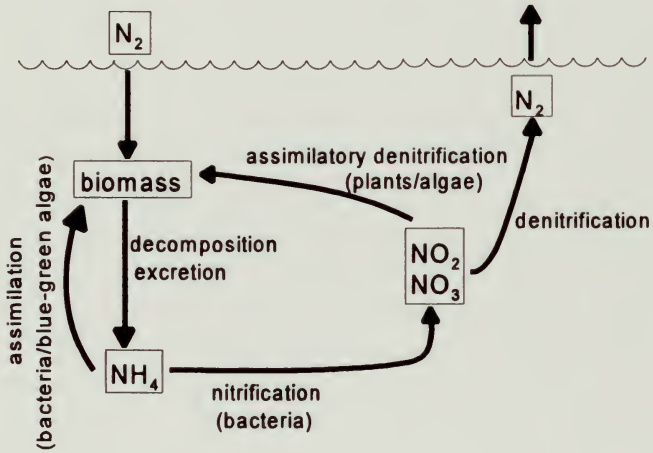
alkalinity— This is the buffering ability of water to resist decreases in pH. This is typically due to carbonate-bicarbonate buffering systems.

hardness— The amount of calcium and magnesium in water constitute water hardness, most often. These cations are usually related to carbonate-bicarbonates, and this measurement is referred to as carbonate hardness.

phosphorus— Phosphorus is essential for life. Most soluble phosphorus occurs in one form--orthophosphate ($PO_4^{\equiv}$). The three possible forms of phosphorus--orthophosphate, monophosphate, and dihydrogen phosphate--together make up the total phosphorus in a lake system. Phosphorus originates from rocks and soils, and although it is abundant on earth, it is often the limiting nutrient in a lake system. In other words, nitrogen and other elements are available in quantities sufficient for rapid growth and reproduction, but there isn't enough phosphorus to maintain that rate. Phosphorus passes through the biotic component of a lake by first being taken up from weathered rocks by plants. Organisms feed on the plants for their phosphorus source. Phosphorus is again made available to the system through excretion and decomposition, and the rate of release and uptake governs the phosphorus cycle in a lake. It can be lost from the system if phosphorus settles on the sediment and is unable to be recycled.

nitrogen— Nitrogen is present in lakes in many forms, and its availability is essential to life. It is the major component of air, but in the water, N_2^- must be converted through a process called biological fixation into one of several usable forms before being incorporated into the phytoplankton. The resulting ammonia (NH_4^+) can be assimilated by plants. Ammonia is also available as a waste product from aquatic organisms, and through a process called nitrification, it can be converted by bacteria, fungi, and

autotrophic organisms into nitrite (NO_2^-) or nitrate (NO_3^-). The steps are very complex, and the nitrogen cycle is one of the fascinating processes in aquatic systems. This should be considered only a simple version of nitrogen cycling, and more extensive explanations should be sought.



silica— Most organisms require only small amounts of silica (Si), but diatoms, one of the most abundant algae types, use large amounts of silica for their frustules (cell wall). Because diatoms are such a crucial component in lake ecosystems, silica availability is important to a lake. Silica in lakes originates from rock weathering. Over the course of the year, concentrations in the water vary depending on rates of dissolution and uptake. The silica in diatoms often settles to the sediment, and large amounts of silica and nutrients can be lost from the system this way. Dissolution is slow, and the rate of release depends on temperature and currents.

Biotic components:

primary productivity— This is the process of photosynthesis in which light and nutrients are assimilated to form energy. Plants are, therefore, the basis for creating energy in a lake. Oxygen is a by-product of photosynthesis, so macrophytes and phytoplankton contribute both a food source and oxygen to the lake system.

phytoplankton— This term literally means "floating plants." The phytoplankton are plants, typically microscopic, that are at the mercy of currents and that rely on sunlight and nutrients dissolved in the water for survival. These are the primary producers of a lake, and the range of survival requirements in different groups of algae is broad. Nutrient availability and competition for resources structures the phytoplankton community. Differences among the groups can be found in pigment composition, morphology, and ecology. Because they are light-dependent, algae are found where light penetrates the water column. Motility is limited, but with the use of projections or by changing their density, algae can maintain a position near the water surface. Some of the major phytoplankton groups found in freshwater include the blue-green algae, green algae, golden-brown algae, and diatoms.

macrophytes— This group of plants are larger than the phytoplankton, and they can be found either floating or attached to the substrate. These are typically found in the lake's littoral zone. Physiological modifications in plant structures allow the macrophytes to exist in water, and many of the same factors that determine phytoplanktonic success influence macrophyte survival: nutrients, light, and space.

zooplankton— The zooplankton are floating animals with locomotive abilities that generally feed on the phytoplankton and other zooplankton. They typically range in size from 0.5-3 mm.

Freshwater zooplankton communities are primarily composed of three groups of organisms: cladocerans, copepods, and rotifers. Because some are mobile, zooplankton are able to migrate vertically, thereby avoiding potential predators during the day. Availability of food and prevalence of predation determine zooplankton community composition.

benthos— This term refers to organisms living in the sediment or the sediment-water interface. Commonly, this refers only to animals (zoobenthos). The large invertebrates and macroinvertebrates have been most extensively studied. In oligotrophic lakes, benthos are diverse and abundant, but in eutrophic lakes, the oxygen-depleted environment is suitable only for a few benthic species. Benthos rely on primary producers as a food source, from benthic-dwelling plants (phytobenthos), sinking phytoplankton, or decomposing phytoplankton.

Sampling:

water sampling— In addition to surface water samples, there are instruments available that allow samples to be collected from discrete depths. Using a Kemmerer water sampler, any depth in the lake can be sampled, provided there is enough rope. The collected sample can then be analyzed for many of the variables described. With this capability, hypolimnion water can be tested separate from epilimnion water, so water conditions through the water column can be characterized.

sampling for ambient conditions— Temperature, dissolved oxygen, pH, and conductivity are all variables that should be measured *in situ*. These parameters are subject to much fluctuation, and dramatic changes occur almost immediately after water has been removed from the lake. In order to measure these variables at depth, a device such as a YSI multiprobe sonde or a

Hydrolab sonde can be used. These will take continuous measurements as they are lowered through the water column, and they will record the depth at which each measurement was taken.

sediment sampling— Grab samples from the bottom of a lake can be collected with an Ekman dredge. This device is cocked open using quick-release springs and lowered to the bottom. When it is resting on the bottom, a triggering weight (called a messenger) attached to the rope is dropped. This trips the Ekman jaws to release and grab a portion of the sediment. The dredge is pulled up to the water surface, and the sample is collected.

zooplankton sampling— Zooplankton are typically collected using a fine-meshed net. A vertical lake sample can be collected by lowering the net to the bottom and then slowly raising it to the surface. In the process, zooplankton of a certain size are retained in the net, and smaller organisms, including most phytoplankton, are strained through the mesh. If only shallow-dwelling zooplankton are desired, a horizontal tow near the surface can be done.

phytoplankton sampling— A net with a finer mesh can also be used for phytoplankton, but they may be broken up in the process. Phytoplankton can be collected with a Kemmerer water sampler just as water is collected for chemical analysis. In the laboratory, the water is then concentrated so that only a small amount of water, with many phytoplankton, is examined under the microscope.

benthos sampling— Sampling for benthos is almost identical to sampling for sediment. An Ekman grab is used to bring a portion of the sediment from the lake bottom to the surface. Usually, the sediment is sieved immediately so that only the organisms are brought back from the field. The sieve has a known mesh size so that organisms of a certain size (macrobenthos) are retained, and

smaller organisms are strained through with the water, silt, and sand.

REFERENCES

Cited References:

Kamke, K.K. Limnology of four lakes in Pictured Rocks National Lakeshore [thesis]. Stevens Point: University of Wisconsin at Stevens Point; 1987. 153 p.

Wetzel, 1987. Limnology. 2nd edition. Orlando: Harcourt Brace Jovanovich, Inc. 767 p.

YSI 6920 Instruction Manual and Service Manual. YSI Incorporated, Yellow Springs, Ohio.

Additional References:

Art, H.W. [editor]. 1993. The dictionary of ecology and environmental science. New York: Henry Holt and Company, Inc. 632 p.

Brower, J.E. and J.H. Zar. 1984. Field and Laboratory Methods for General Ecology. 2nd edition. Dubuque, Iowa: Wm. C. Brown Publishers. 226 p.

Cole, G.A. 1979. Textbook of Limnology. 2nd edition. St. Louis: The C.V. Mosby Company. 426 p.

Horne, A.J. and C.R. Goldman. 1994. Limnology, 2nd edition. New York: McGraw-Hill, Inc. 576 p.

Lind, O.T. 1979. Handbook of common methods in Limnology. 2nd edition. St. Louis: The C.V. Mosby Company. 199 p.

Wetzel, R.G. and G.E. Likens. 1979. Limnological Analyses. Philadelphia: W.B. Saunders Company. 357 p.